WE CLAIM:

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1. A method of fusing optical fiber, comprising:

Placing a first optical fiber formed of a silica glass and a second optical fiber formed of a first low-temperature multi-component glass in an end-to-end configuration with a small gap separating the fibers, said second multi-component glass having a softening point temperature that is lower than that of said silica glass;

Asymmetrically heating the fibers to raise the temperature of the first optical fiber (T_{si}) and the second optical fiber (T_{mc}) such that $T_{si} > T_{mc}$ at the gap between the fibers, $T_{mc} > T_{mc\text{-}soft}$ where $T_{mc\text{-}soft}$ is the softening temperature of the first multi-component glass, $T_{si} < T_{si\text{-}soft}$ where $T_{si\text{-}soft}$ is the softening temperature of the silica glass; and

Moving the fibers together such that said fibers form thermal diffusion bonds between the first optical fiber and the second optical fiber.

2. The method of claim 1, wherein the step of asymmetrically heating the fibers includes:

Placing a heating element proximate the silica glass at a distance d from the small gap separating the fibers; and

Activating the heating element to generate heat.

3. The method of claim 2, wherein the heating element comprises a pair of electrodes that are placed on either side of the first optical fiber to generate an arc that heats the first optical fiber.

4. The method of claim 2, wherein the heating

element comprises a heating filament that lies at least partially around the first optical fiber.

5. The method of claim 2, wherein the heating element localizes the heat onto the first optical fiber, which in turn acts as a heating element to heat the second optical fiber.

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6. The method of claim 2, wherein the bond between the fibers has a pull-strength in excess of 100g.

7. The method of claim 2, wherein the first low-temperature multi-component glass comprises a glass network former selected from one of (phosphorus oxide P_2O_5 or germanium oxide GeO_2) from 30 to 80 percent, a glass network modifier MO from 5 to 40 percent, and a glass network intermediator L_2O_3 from 5 to 30 percent, wherein MO is selected from alkaline earth oxides and transition metal oxides consisting of BaO, BeO, MgO, SrO, CaO, ZnO, PbO and mixtures thereof, and L_2O_3 is selected from Al_2O_3, B_2O_3, Y_2O_3, La_2O_3, and mixtures thereof.

8. The method of claim 2, wherein said second optical fiber is drawn with an outer cladding formed from a second multi-component glass having a softening temperature higher than the first multi-component glass and a glass network that is more compatible with forming strong thermal diffusion bonds with the silica glass.

9. The method of claim 8, wherein said second multi-component glass is a silicate glass that comprises a glass network of silicon oxide (SiO_2) from 30 to 80 percent, a glass network modifier MO from 5 to 40 percent, and a glass network intermediator L_2O_3 from 5 to 30 percent, MO is

selected from alkaline earth oxides and transition metal oxides consisting of BaO, BeO, MgO, SrO, CaO, ZnO, PbO and mixtures thereof, and L_2O_3 is selected from Al_2O_3, B_2O_3, Y_2O_3, La_2O_3, and mixtures thereof.

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10. The method of claim 8, further comprising the step of first:

manufacturing a preform that includes the core and the inner cladding formed from the first multi-component glass and the outer cladding formed from the second multi-component glass; and

drawing the preform to form the second optical fiber.

11. A method of fusing optical fibers, comprising:

Placing a first optical fiber formed of a silica glass and a second optical fiber in an end-to-end configuration with a small gap separating the fibers, said second optical fiber comprising a core formed from a first low-temperature multi-component glass and an outer cladding formed from a second multi-component glass, said second multi-component glass having a softening point temperature that is higher than that of said first multi-component glass yet compatible with drawing both glasses to form said second optical fiber, said second multi-component glass having a glass network that is more compatible than that of said first multi-component glass with forming strong thermal diffusion bonds with the silica glass;

Generating heat that causes said second optical fiber to soften while said first optical fiber does not soften; and

Moving the fibers together such that said fibers form thermal diffusion bonds between the first optical fiber and the second optical fiber's outer cladding.

12. The method of claim 11, wherein said first multi-component glass is selected from one of phosphate or germanate and said second multi-component glass is silicate.

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13. The method of claim 12, wherein said first multi component glass comprises a glass network former selected from one of (phosphorus oxide P_2O_5 or germanium oxide GeO_2) from 30 to 80 percent, a glass network modifier MO from 5 to 40 percent, and a glass network intermediator L_2O_3 from 5 to 30 percent, wherein MO is selected from alkaline earth oxides and transition metal oxides consisting of BaO, BeO, MgO, SrO, CaO, ZnO, PbO and mixtures thereof, and L_2O_3 is selected from Al_2O_3, B_2O_3, Y_2O_3, La_2O_3, and mixtures thereof.

14. The method of claim 13, wherein for the phosphorus oxide P_2O_5 glass network former the glass network modifier MO is from 5 to 30 percent.

15. The method of claim 13, wherein the second optical fiber's core is doped with 0.5 to 5 wt. % erbium and 0.5 to 30 wt. % ytterbium.

16. The method of claim 13, wherein said second multi component glass comprises a glass network of silicon oxide (SiO_2) from 30 to 80 percent, a glass network modifier MO from 5 to 40 percent, and a glass network intermediator L_2O_3 from 5 to 30 percent, MO is selected from alkaline earth oxides and transition metal oxides consisting of BaO, BeO, MgO, SrO, CaO, ZnO, PbO and mixtures thereof, and L_2O_3 is selected from Al_2O_3, B_2O_3, Y_2O_3, La_2O_3, and mixtures thereof.

17. The method of claim 12, wherein said silica fiber

has a softening temperature greater than 1200°C, said first multi-component glass has a softening temperature less than 600°C and said second multi-component glass has a softening temperature less than 800°C, said fibers being heated to a temperature between 800°C and 1200°C.

18. The method of claim 11, wherein said first multi-component glass is phosphate and said second multi-component glass is tellurite.

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19. The method of claim 18, wherein said first multi component glass comprises telluride oxide TeO_2 from 30 to 80 percent, a glass network modifier MO from 2 to 40 percent, and a glass network intermediator XO from 2 to 30 percent, wherein MO is selected from alkaline earth oxides and transition metal oxides consisting of BaO, BeO, MgO, SrO, CaO, ZnO, PbO and mixtures thereof, and XO is selected from PbO, ZnO, WO_3, Al_2O_3, B_2O_3, Y_2O_3, La_2O_3, and mixtures thereof.

20. The method of claim 18, wherein said second multi component glass comprises a glass network of phosphorus oxide P_2O_2 from 30 to 80 percent, a glass network modifier MO from 5 to 40 percent, and a glass network intermediator L_2O_3 from 5 to 30 percent, MO is selected from alkaline earth oxides and transition metal oxides consisting of BaO, BeO, MgO, SrO, CaO, ZnO, PbO and mixtures thereof, and L_2O_3 is selected from Al_2O_3, B_2O_3, Y_2O_3, La_2O_3, and mixtures thereof.

21. The method of claim 18, wherein said silica fiber has a softening temperature greater than 1200°C, said tellurite glass has a softening temperature less than 400°C and said phosphate glass has a softening temperature less than 600°C, said fibers being heated to a temperature

between 600°C and 1200°C.

22. The method of claim 11, wherein said second optical fiber further comprises an inner cladding around said core, said inner cladding being formed from said first multi-component glass.

23. The method of claim 22, wherein said outer cladding has a refractive index that exceeds that of said inner cladding.

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24. The method of claim 22, further comprising the step of first:

manufacturing a preform that includes the core and the inner cladding formed from a first multi-component glass and the outer cladding formed from a second multi-component glass; and

drawing the preform to form the second optical fiber.

25. The method of claim 24, wherein the preform is manufactured by:

Forming a glass ingot from the first multi-component glass;

Coring the glass ingot to produce a core glass rod;

Inserting the core glass rod into an inner cladding glass tube also formed from the first multi-component glass to form an assembly;

Drawing the assembly into a glass rod;

Inserting the glass rod into an outer cladding glass tube formed from the second multi-component glass to form the preform; and

Drawing the preform into the second optical

fiber.

26. The method of claim 25, wherein the glass ingot is doped with rare-earth elements.

27. The method of claim 24, wherein the preform is manufactured by:

Forming a glass ingot from the first multi-component glass;

Coring the glass ingot to produce a core glass rod;

Inserting the core glass rod into an inner cladding glass tube also formed from the first multi-component glass to form an assembly;

Inserting the assembly into an outer cladding glass tube formed from the second multi-component glass to form the preform; and

Drawing the preform into the second optical fiber.

28. The method of claim 11, wherein said outer cladding is formed on the surface of the core.

29. The method of claim 28, wherein said second multi-component glass is designed and manufactured to reduce the diffusion of OH- ions from the outer cladding into the core.

30. The method of claim 28, further comprising the step of first:

Forming a glass ingot from the first multi component glass;

Coring the glass ingot to produce a core glass rod;

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Inserting the core glass rod into an outer cladding glass tube formed from the second multi-component glass to form a preform; and

Drawing the preform into the second optical fiber.

31. The method of claim 11, wherein the cross-sectional area of the outer cladding is at least 50% of the cross-sectional area of the second optical fiber.

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32. The method of claim 31, wherein the optical properties of the second optical fiber are determined by the first multi-component glass and the mechanical properties are dominated by the thermal diffusion bonds between silica and the second multi-component glass.

33. The method of claim 11, wherein heating the fibers so that only the second optical fiber softens causes the second optical fiber's core to taper to a larger diameter at the bond between the two fibers.

34. The method of claim 33, wherein the taper approximately matches the mode fields in the fiber cores.

35. The method of claim 11, wherein a heating element is positioned proximate the first optical fiber a distance d_0 from the gap separating the fibers.

36. The method of claim 35, wherein said heating element asymmetrically heats said fibers to raise the temperature of the first optical fiber above the temperature of said second optical fiber thereby creating a temperature gradient at the gap between the two fibers with the temperature of said second optical fiber being above

the softening temperature of both said first and second multi-component glasses.

37. The method of claim 36, wherein the second optical fiber has an end face that is exposed to the first optical fiber at the gap, the heating elements heating said first optical fiber thereby transferring heat down the first optical fiber to the gap to heat and soften the second optical fiber's end face.

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38. A method of drawing a multi-component fiber that is compatible with fusion splicing to a silica fiber, comprising:

manufacturing a preform that includes a core and an inner cladding formed from a first multi-component glass and an outer cladding formed from a second multi-component glass, said second multi-component glass having a softening point temperature that is higher than that of said first multi-component glass and having a glass network that is more compatible than that of said first multi-component glass with forming strong thermal diffusion bonds with silica glass; and

drawing the preform to form the multi-component fiber.

39. The method of claim 38, wherein the preform is manufactured by:

Forming a glass ingot from the first multi-component glass;

Coring the glass ingot to produce a core glass rod;

Inserting the core glass rod into an inner cladding glass tube also formed from the first multi-component glass to form an assembly;

Drawing the assembly into a glass rod;

Inserting the glass rod into an outer cladding glass tube formed from the second multi-component glass to form the preform; and

Drawing the preform into the second optical fiber.

40. The method of claim 39, wherein the glass ingot is doped with rare-earth elements.

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41. The method of claim 38, wherein the preform is manufactured by:

Forming a glass ingot from the first multi-component glass;

Coring the glass ingot to produce a core glass rod;

Inserting the core glass rod into an inner cladding glass tube also formed from the first multi-component glass to form an assembly;

Inserting the assembly into an outer cladding glass tube formed from the second multi-component glass to form the preform; and

Drawing the preform into the second optical fiber.

42. A method of fusing optical fiber, comprising:

Placing a first optical fiber formed of a silica glass and a second optical fiber formed of a first low-temperature multi-component glass in an end-to-end configuration with a small gap separating the fibers, said second optical fiber comprising a core formed from a first low-temperature multi-component glass and an outer cladding formed from a second multi-component glass, said second multi-component glass having a softening point temperature

that is higher than that of said first multi-component glass yet compatible with drawing both glasses to form said second optical fiber, said second multi-component glass having a glass network that is more compatible than that of said first multi-component glass with forming strong thermal diffusion bonds with the silica glass;

Asymmetrically heating the fibers to raise the temperature of the first optical fiber (T_{si}) and the second optical fiber (T_{mc}) such that $T_{si} > T_{mc}$ at the gap between the fibers, $T_{mc} > T_{mc2-soft}$ where $T_{mc-soft}$ is the softening temperature of the second multi-component glass, $T_{si} < T_{si-soft}$ where $T_{si-soft}$ is the softening temperature of the silica glass; and

Moving the fibers together such that said fibers form thermal diffusion bonds between the first optical fiber and the second optical fiber.

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43. The method of claim 42, wherein the step of asymmetrically heating the fibers includes:

Placing a heating element proximate the silica glass at a distance d_o from the small gap separating the fibers; and

Activating the heating element to generate heat.

44. The method of claim 43, wherein the heating element localizes the heat onto the first optical fiber, which in turn acts as a heating element to heat the second optical fiber.

45. The method of claim 43, wherein the bond between the fibers has a pull-strength in excess of 100g.

46. The method of claim 42, wherein the first multi-

component glass is phosphate or germanate and the second multi-component glass is silicate.

47. The method of claim 42, wherein the first multi-component glass is tellurite and the second multi-component glass is phosphate.

48. The method of claim 42, wherein the cross-sectional area of the outer cladding is at least 50% of the cross-sectional area of the second optical fiber so that the optical properties of the second optical fiber are determined by the first multi-component glass and the mechanical properties are dominated by the thermal diffusion bonds between silica and the second multi-component glass.

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